LTB CKD Release Site
Mercury Flux Model Protocol
FINAL
April 2009

This document serves to establish and memorialize the protocol for implementing the mercury flux model for the purpose of predicting mercury venting to the lake at both the East Park and the Development Side of the Little Traverse Bay CKD Release Site, Emmet County, Michigan.

A discrete model using site specific data within a given site sub-area has been developed to model the mercury discharge along the shoreline. The model is based on Darcy's equation whereby the groundwater flux is calculated using the Darcy flow equation below:

Q (flow) = K * I * A

Where:

K - hydraulic conductivity

I - hydraulic gradient

A - Area of flux boundary

The mercury flux is calculated using the basic equation below:

M (mercury flux) = C * Q

Where:

C - concentration

Q - flow

Application of the discrete analysis method to the site requires that discrete hydraulic conductivity, hydraulic gradient, and concentration from a specific well screen represent a simple vertical area along the lakeshore. The product of the area, the well-specific parameters, and the concentration yields a discrete mercury flux for the specific zone for a particular well screen. The sum of each discrete mercury flux for all well screens yields the total mercury flux for a given geologic zone. Rules for determining each of the parameters are outlined below:

Area: The discrete flux zones or individual areas surrounding each well are determined by the following:

- The area is a simple rectangle surrounding a specific well screen.
- The horizontal extent of each discrete flux zone is bounded by the midpoints of adjacent well nests.

- The flux model outer horizontal boundary shall be located half the distance from "book-end" well to the next interior well adjacent to the "book-end" well.
- The vertical extent of each flux zone shall be the midpoint between well screens at a given location; this rule shall be modified by the following two conditions:
    - The shallowest discrete flux zone shall be determined from the groundwater table elevation to the midpoint between the shallowest and next well screen interval.
    - The lowest discrete flux depth shall be determined by linearly interpolating between the deepest impact (defined as concentration greater than 1.3 ng/L) and the next lower screen.

Hydraulic Conductivity:

Mini-pump test shall be performed in all 50 shoreline wells using a variety of pumps as noted in the ECKD mini pump test work plan approved by EPA on April 7, 2009. Following completion of all mini-pump tests and initial data analysis, results shall be submitted to EPA for review.

In cases where the mini pumps test results do not appear to be accurate, retesting of the well will occur. The data will be evaluated jointly by CMS and EPA to identify unsuccessful mini-pump test results, if any, based on the following criteria:

- Insufficient drawdown;
- Significant influence from Lake Michigan that masks the effects of pumping: or
- The well is pumped dry at the lowest possible pumping rate too quickly to obtain usable data.

Should the evaluation of the mini-pump test results identify wells for which the mini-pump tests were unsuccessful according to the above criteria, additional evaluation will be performed to determine hydraulic conductivity values for those well screens. The following approach shall be taken in this situation:

- CMS shall submit to EPA a written proposal to evaluate slug test results and mini-pump tests with the goal of developing a site-specific correction factor to adjust the hydraulic conductivity value for individual wells where a mini-pump test was unsuccessful. The correction factor will be determined by performing a regression analysis using the slug test and mini-pump test data from East Park wells where mini-pump tests were completed successfully. The written proposal for development of a correction factor shall be submitted by CMS within thirty (30) days of submittal of pump test data to the Agency for review (and modification, if necessary) and acceptance.

Note, separate correction factors may be developed for hydro-geologically distinct zones at East Park (West and North-shore zones) as needed.

Slug tests shall be performed, using the same procedures as before, at well screens where a mini-pump test was unsuccessful and where no other slug test data exists. Thereafter, the slug test result shall be corrected in accordance with the established correction factor.

Hydraulic Gradient:

A discrete hydraulic gradient will be determined for each well screen. The hydraulic gradient for a given well shall be defined as the difference between the groundwater elevation in the well and the lake elevation, divided by the horizontal distance between the well and the lake.

As outlined below, owing to short-term fluctuations in both lake and groundwater elevations, use of electronic water level transducers shall be required at selected locations to record changes in lake and groundwater elevations over a minimum 24-hour period. For wells in which electronic water level transducers are used, a 24-hour average hydraulic gradient will be calculated and used in the flux calculation.

An on-site stilling well shall be installed within Village Harbor Lake to continuously record lake elevations during the groundwater sampling events. Lake elevation measurements should be accurate to 0.01 ft, and referenced to the same vertical datum used for the site monitoring wells. Lake elevations should be measured and stored electronically at approximately 10-minute time intervals. .

Electronic water level transducers shall be used in all of the wells for at least one sampling event (e.g., initial sampling event) to provide a continuous 24-hour record of groundwater elevation changes in each well. The 24-hour record should correspond to the period immediately preceding or following the sampling event, and should coincide with a period for which continuous lake elevation records are available for comparison. Groundwater elevations should be measured and stored electronically at approximately 10-minute time intervals, and measurements should be accurate to 0.01 ft. The groundwater elevation data from the initial sampling event should be submitted to EPA within 30 days of collection.

Subsequently, use of electronic water level transducers shall be required for all shoreline wells exhibiting a groundwater elevation difference relative to the lake of 0.5 feet or less, as determined by a single point measurement at the time of sampling. CMS shall propose a list of selected shoreline wells to EPA for consideration and approval prior to installation of the pressure transducers. Transducer measurement procedures and accuracy should be the same as for the initial sampling event. Following the initial sampling event, use of transducers will not be required for wells exhibiting groundwater elevation differences greater than 0.5 relative to the lake at the time of sampling.

The distance from each monitoring well nest to the lake shore shall be based on a site survey of the lake edge ground surface in the vicinity of each well measured to the nearest tenth of a foot vertically. The horizontal distance between the each well and the lake shall be determined to the nearest 1 foot.

Hydraulic gradients will be calculated as a point measurement with corresponding point groundwater and lake elevations and distance to the shoreline for wells in which water level pressure transducers are not used. For wells where continuous groundwater elevation data are collected, 24-hour average hydraulic gradients will be calculated using the 24-hour average groundwater elevation for the 24-hour period following a groundwater analytical sampling event, the 24-hour average lake elevation and the 24-hour average distance to the shoreline.

To minimize potential bias in the gradient determination caused by extreme lake conditions, groundwater elevation monitoring shall not be conducted during extreme weather events such as high wave conditions or heavy rainfall.

Concentration:

The concentrations for a given well shall be assumed to be constant over the area represented by the well screen. Further, a mercury concentration of 1/2 the detection limit (0.25ng/L) shall be substituted for the lower most flux zone at any given well nest where a non-detect concentration is reported.